Cosmology Course

Matter in the Universe:

Galaxies and Their Evolution

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Bibliography

- Cosmological Physics, John Peacock (1999)
- Galactic Astronomy, Binney and Merrifield (1998)

SPECIFIC INTENSITY	I_ν	$W m^{-2} Hz^{-1} sr^{-1}$
FLUX DENSITY	S_ν	$W m^{-2} Hz^{-1}$

$Jy \equiv 10^{-26} W m^{-2} H$

ABSOLUTE MAGNITUDE AND K- CORRECTION

$$\Delta \ln S = 0.92103 \, \Delta m$$

$$m = M + 5 \log_{10} \left(\frac{D_L}{10 pc} \right) + K(z)$$

ACCOUNTS FOR THE SHIFT OF THE SPECTRUM IN ν.

The Galaxy Population

Galaxies form a two-parameter family in which the characteristics that vary are the total amount of light and how this is divided between two components:

- The bulge
  *It is supported against gravity through "stellar pressure"
  *Population II of stars (low metallicities)
  *

$$I(r) = I_e \exp\left\{-7.67\left[\left(\frac{r}{r_e}\right)^{1/4} - 1\right]\right\}$$

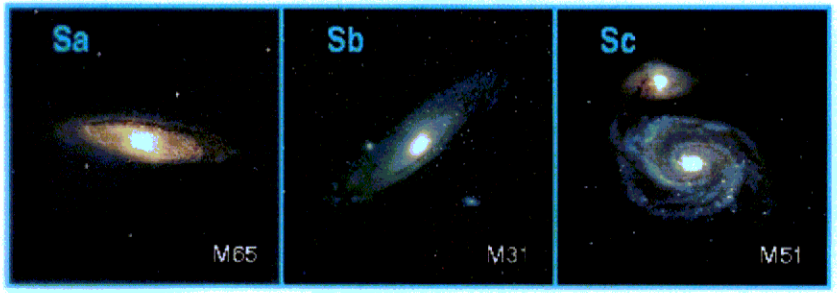
- The disk

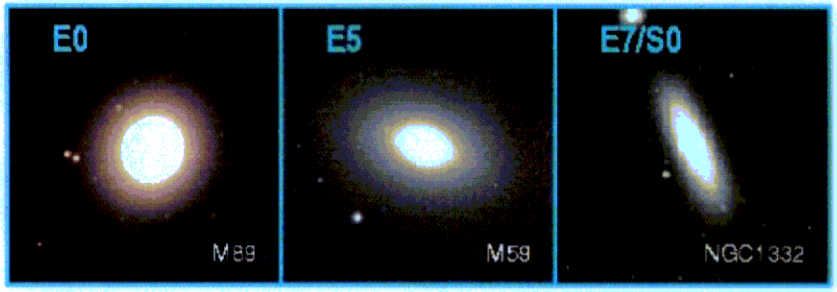
  *Flattened structure, with stars moving in circular orbits

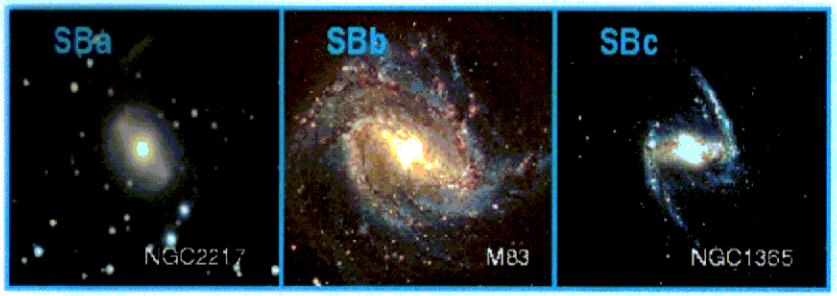
  *Active star formation and associated debris, population I

  *

$$I(r) = I_0 \exp\left(-\frac{r}{r_0}\right)$$







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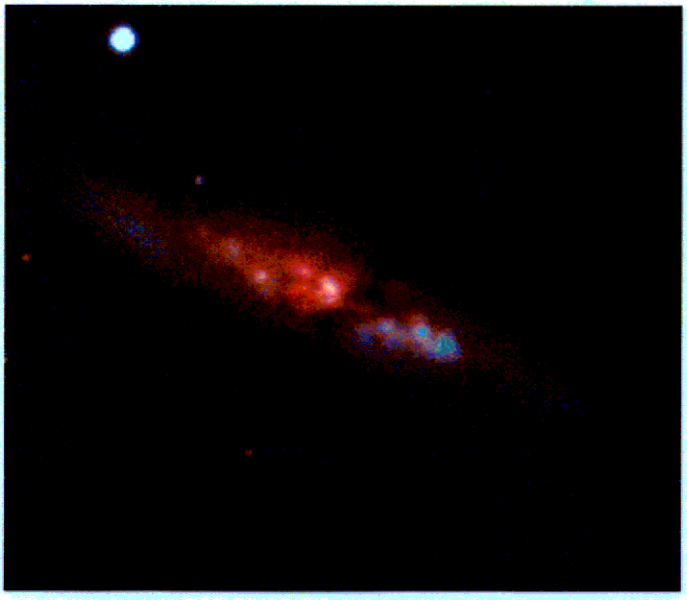
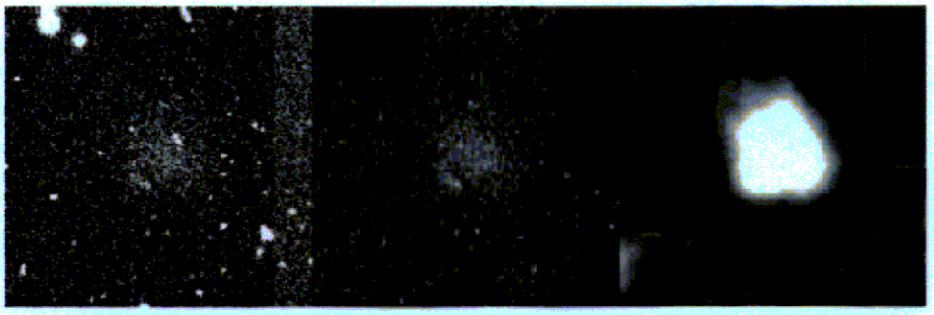
Some galaxies to not fit easily into the Hubble sequence. In general they are low mass systems:

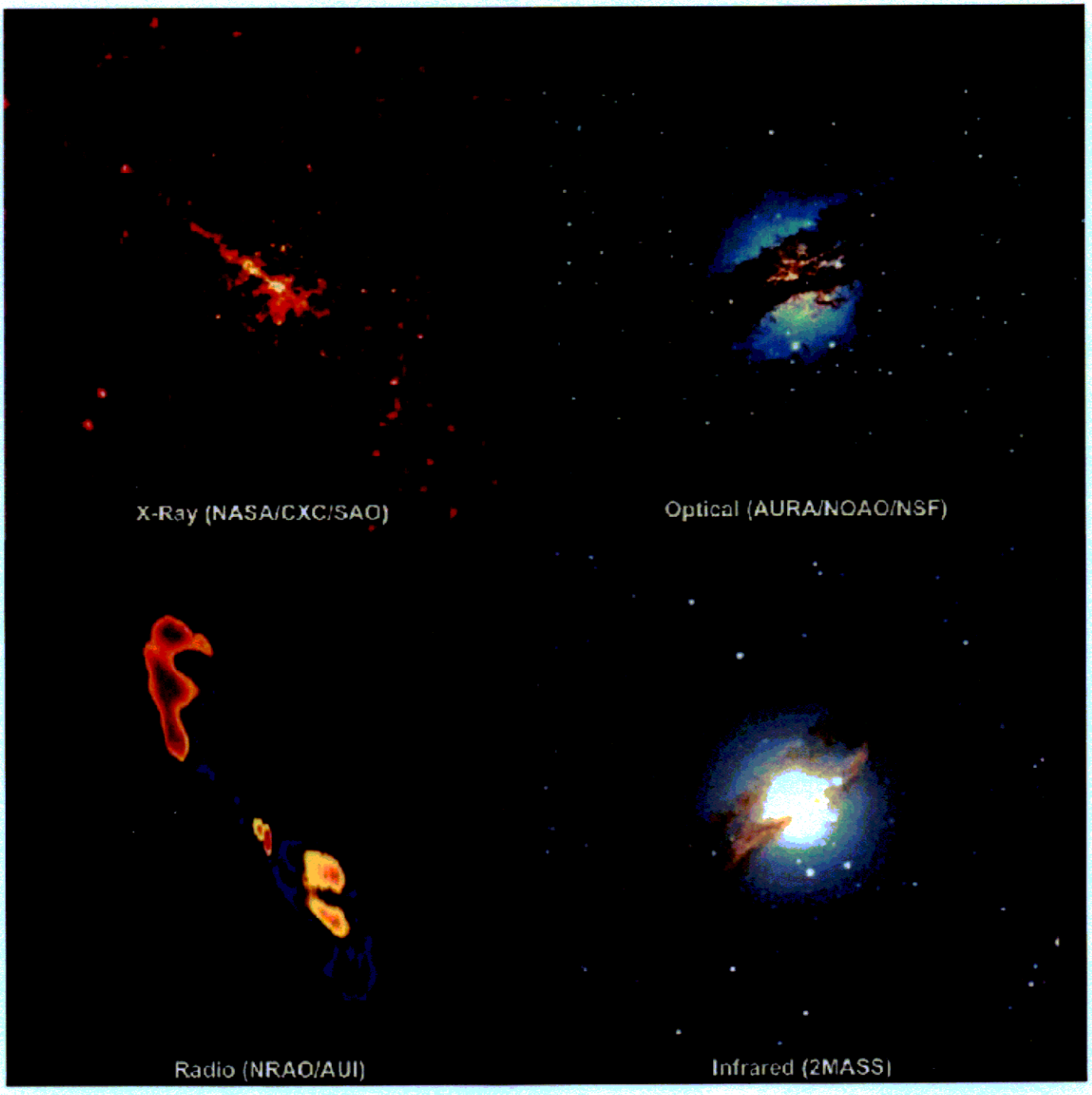
- Dwarf Ellipticals
- Dwarf Irregulars (active stellar formation)
- Dwarf Spheroids

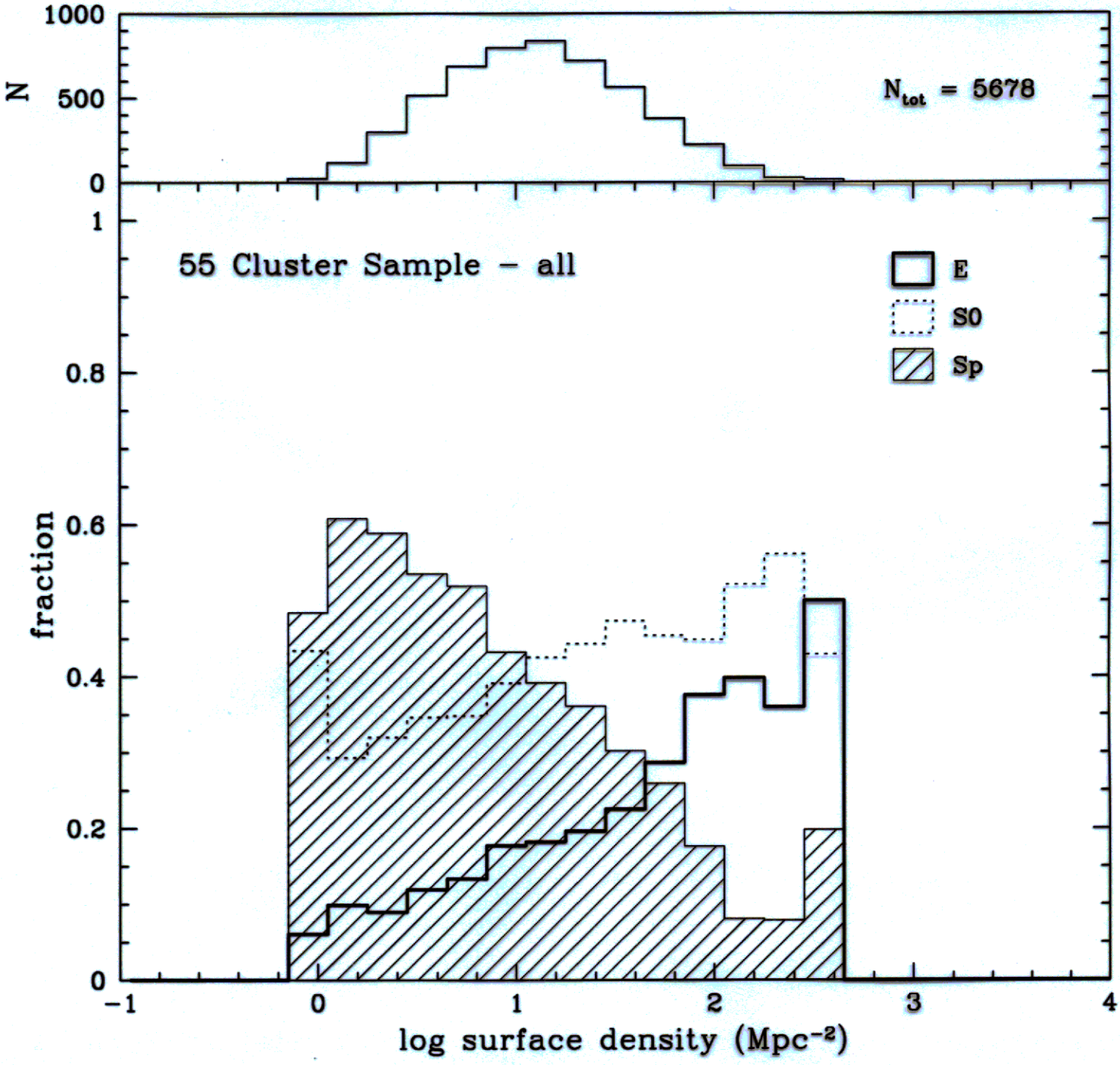
But also "Croucching Giants" such as

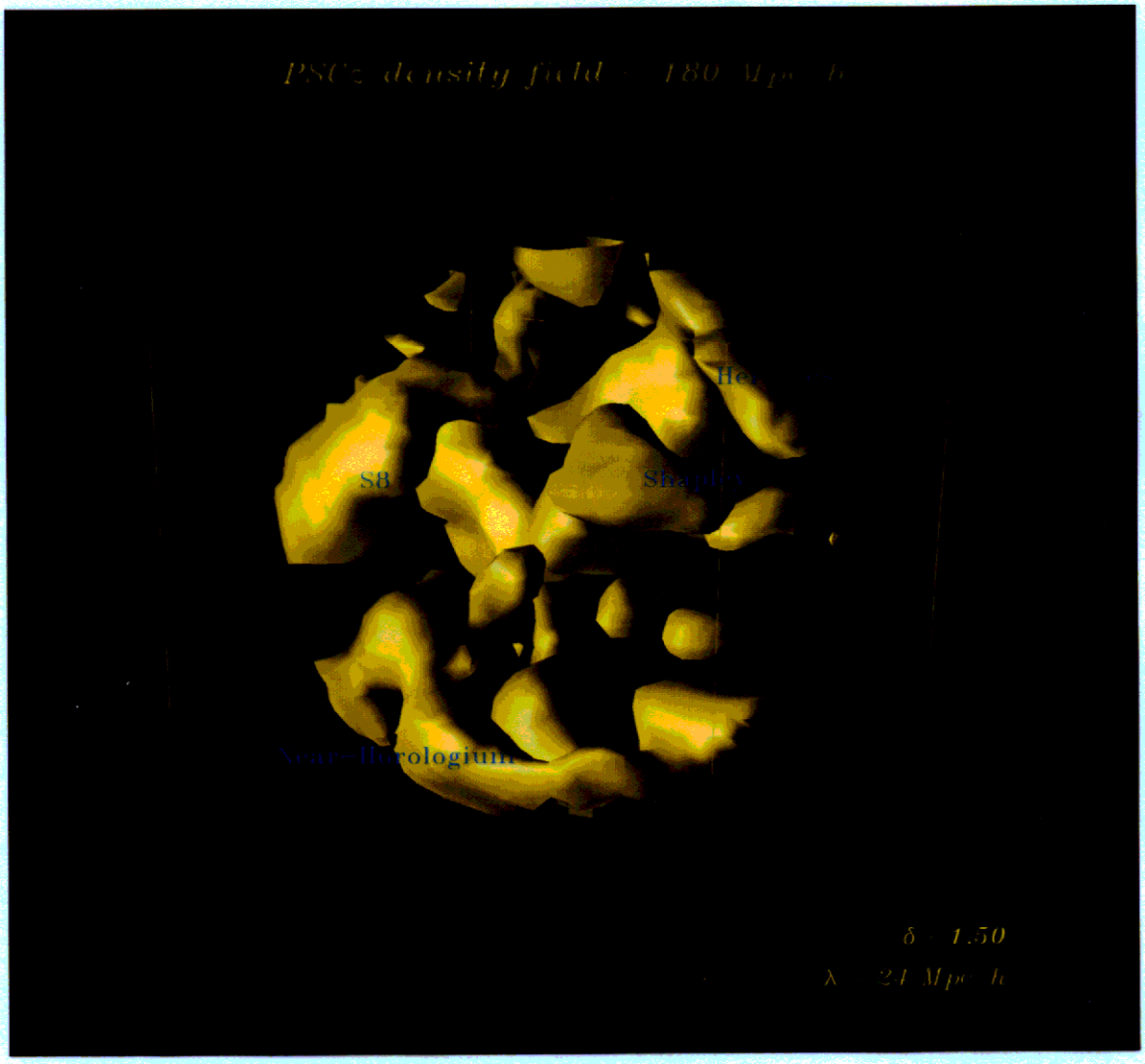
- Low Surface Brightness Galaxies






X-Ray (NASA/CXC/SAO)
Optical (AURA/NOAO/NSF)
Radio (NRAO/AUI)
Infrared (2MASS)

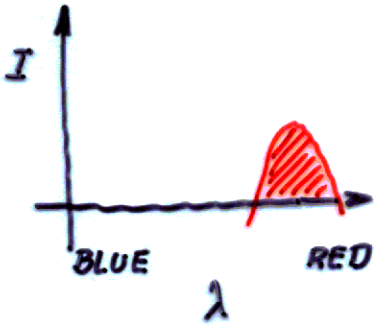

1000
500
0
N
N_{tot} = 5678
55 Cluster Sample – all
E
S0
Sp
1
0.8
0.6
0.4
0.2
0
fraction
−1
0
1
2
3
4
log surface density (Mpc^{-2})


PSCz density field
S8
Shapley
Near-Horologium
δ 1.50

COLOURS AND METALLICITIES

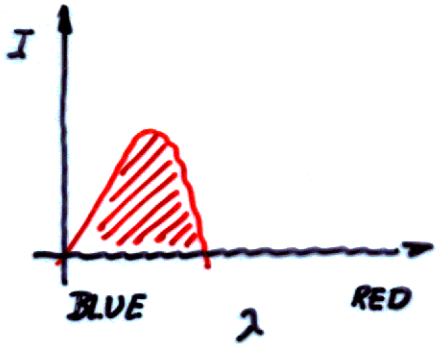
ELLIPTICALS:

- COOL STARS ($T \approx 5000\,°K$) WITH LITTLE DUST AND HEAVILY MODIFIED SPECTRUM BY METALLIC ABSORPTION FEATURES
- $2.3\,\mu m$ CO ABSORPTION => GIANT STARS



SPIRALS:

- SIGNIFICANT STAR FORMATION WITHIN THE PAST G_{yr}
- CONTAIN YOUNG STARS
- PRESENCE OF YOUNG STARS => HII REGIONS



ELEMENT	$\log_{10}(n/n_H)$
He	−1.01
C	−3.40
N	−4.00
O	−3.07
Ne	−3.91
Mg	−4.42
Si	−4.45
Fe	−4.33

$$[A/H] \equiv \log_{10}\left(\frac{n_A/n_H}{n_A^{\odot}/n_H^{\odot}}\right)$$

ELLIPTICALS AND BULGES: $[Mg/Fe] \simeq 0.2 - 0.5$

=> TYPE II SPNOVAE => MASSIVE STARS WERE IMPORTANT IN THE EARLY PHASE OF ELL. EVOLUTION!

METALLICITY: ↑ MASS; ↓ RADIUS

Type	Relative ϕ^*	$M^*_{B_J}(h=1)$
E/SO	0.35	-19.59
Sa	0.07	-19.39
Sb	0.18	-19.39
Sc	0.17	-19.39
Sd	0.15	-18.94
Irr	0.08	-18.94


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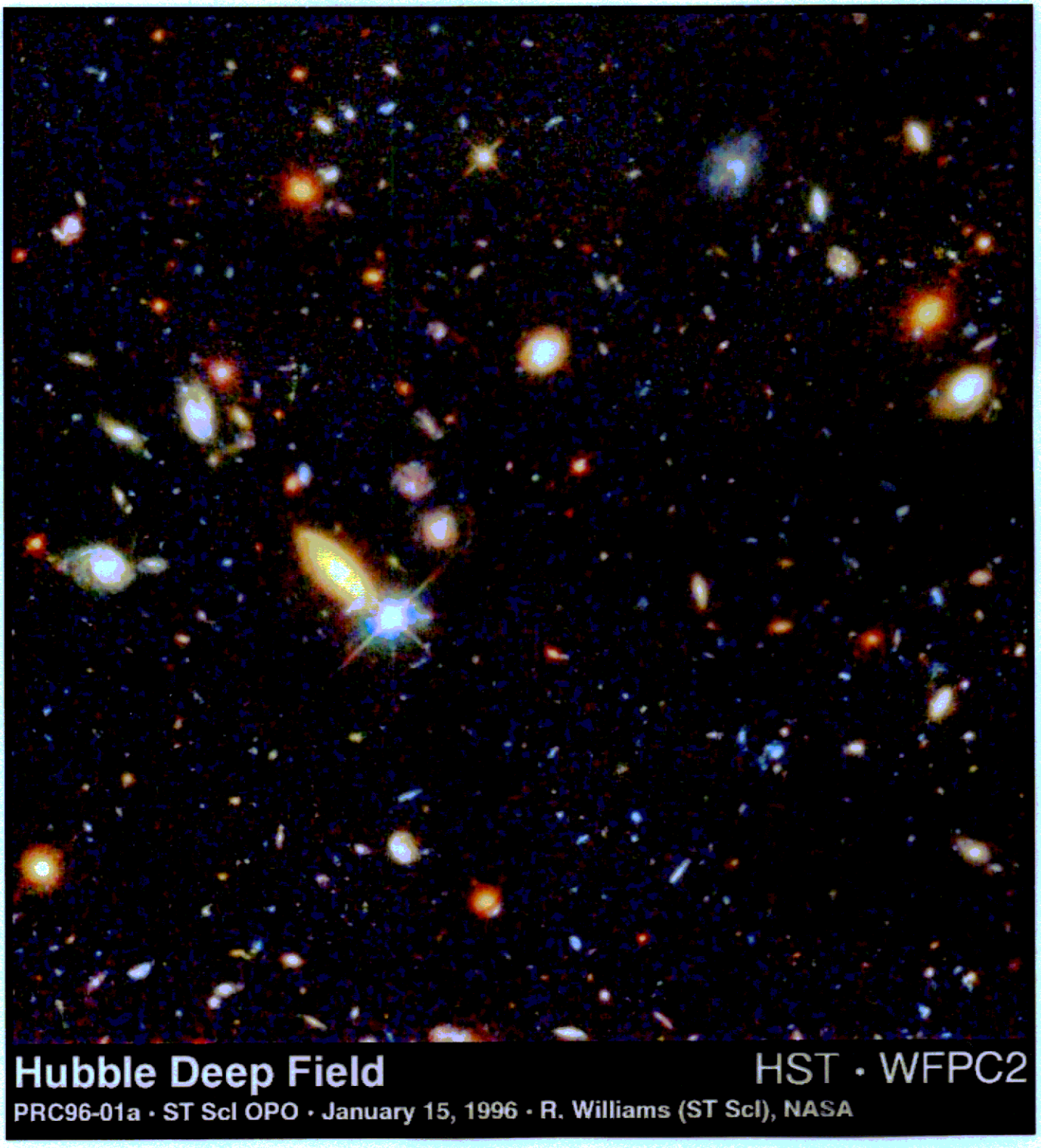
Photo by David Malin

CLUSTER L.F. :

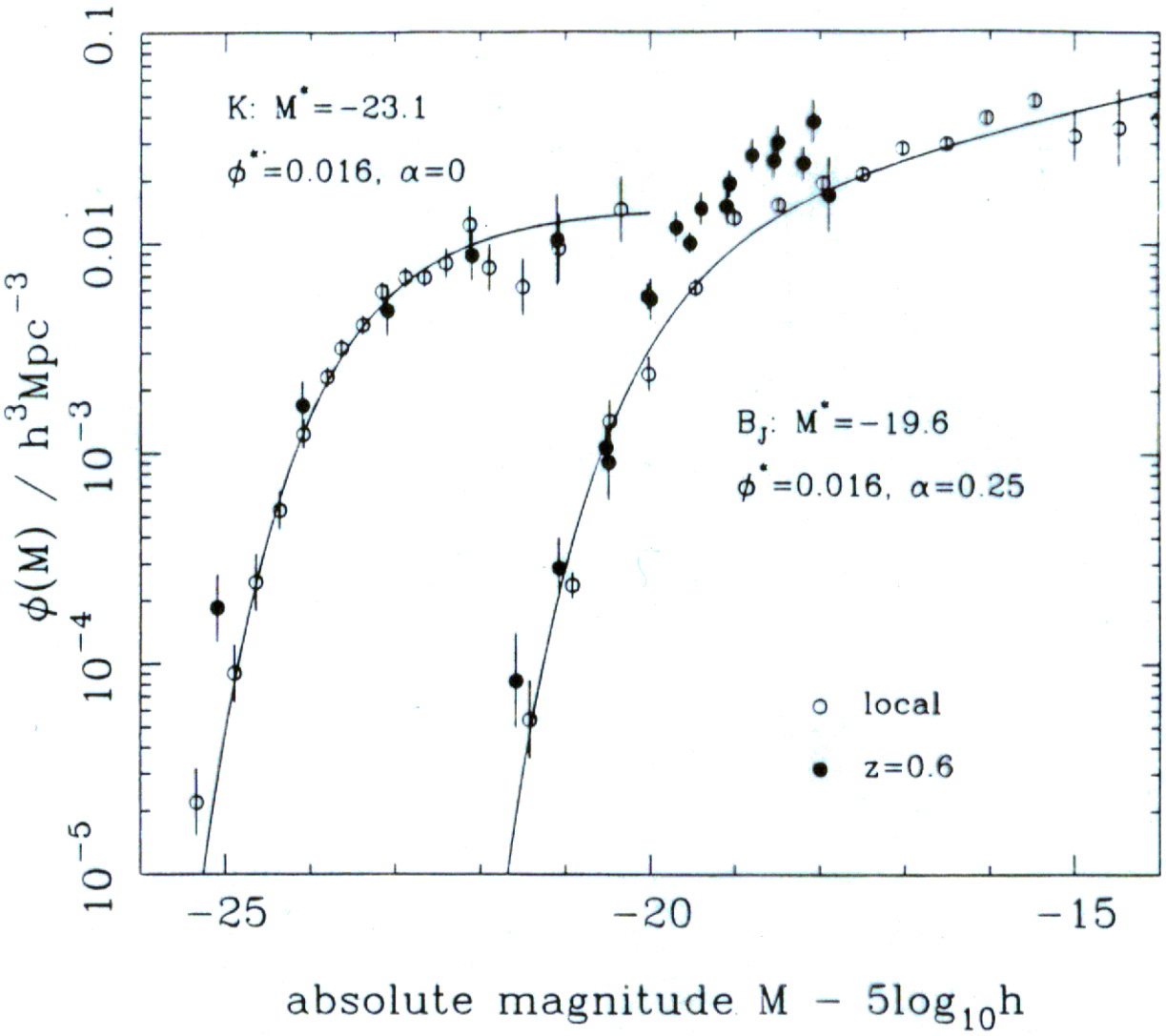
- $\alpha \simeq -1.8$ TOO MANY DWARFS !
- cD GALAXIES DEVIATION FROM THE SCHECHTER FUNCTION =>

  SOMETHING DIFFENT IS GOING ON DURING THE cDs FORMATION !
- L.F DO NOT CHANGE WITH RICHNESS ! => PROBLEMS FOR BIASING !
- BUTCHER-OEMLER EFFECT: LARGER FRACTION OF BLUE GAL. @ HIGHER z !



Hubble Deep Field HST · WFPC2

PRC96-01a · ST ScI OPO · January 15, 1996 · R. Williams (ST ScI), NASA


K: M* = −23.1
φ* = 0.016, α = 0
B_J: M* = −19.6
φ* = 0.016, α = 0.25
local
z = 0.6
φ(M) / h³Mpc⁻³
10⁻⁵
10⁻⁴
10⁻³
0.01
0.1
−25
−20
−15
absolute magnitude M − 5log₁₀h

EVOLUTION OF L.F.s

- INFRARED RESULTS DO NOT CHANGE IN z $\rho_L = \Gamma(\alpha+2)\phi^* L^*$
- BLUE: - THE SPACE DENSITY WAS HIGHER IN THE PAST!

  - BRIGHT END SHOWS LITTLE CHANGE => MASSIVE GAL. ARE ALREADY IN PLACE BEFORE $z = 1$

  - LOWER LUMINOSITY GAL. ARE FOUND IN LARGER NUMBERS THAN @ $z = 0$

  - IT DOES NOT MEAN THAT THE BIG ONES FORM FIRST AND THE SMALL ONES AFTER! STAR FORMATION IN THE MASSIVE GALAXIES COULD BE RELATED WITH MORPHOLOGICAL SEGREGATION!